UNEARTHING NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY
Department of Environmental Protection

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MESSAGE FROM THE STATE GEOLOGIST

This issue of *Unearthing New Jersey* includes articles ranging from the State's historic boundary to its future water supply planning needs. It emphasizes the importance and variety of geology in New Jersey, from the preservation of the northern Highlands region to the collecting of semi-precious stones in Cape May.

Bill Graff recounts some of the complicated history of New Jersey's boundary along the northern land border with New York. He describes the first survey of the northern border in 1774 and the more precise re-survey by New Jersey's first State Geologist, George H. Cook, in 1872. Some of Cook's work and the earlier survey remain today as two stone monuments, unique granite sentinels overlooking the Hudson and Delaware Rivers and define New Jersey, New York and Pennsylvania sovereignty.

Steve Domber provides background on the New Jersey Geological Survey's lead role in quantifying water use and availability for the current update of the State's Water Supply Plan. The plan balances potable, ecological, economic and recreational water needs to ensure sustainable water supplies for the future, especially during drought. New Jersey's projected population increase, from about eight to ten million people by 2030, will require an additional 94 billion gallons of potable water per year. In support of the planning process, the current and projected amount of water withdrawn and the amount that is available for all of New Jersey's watersheds and confined aquifers, is well underway. The expected completion date is December 2006.

Ron Witte provides an excerpt from a new on-line publication called the *Geologic History and Virtual Field Trip of the New Jersey Highlands.* This Adobe Acrobat document provides a "field trip" using text, illustrations, and photographs that describe the origin of the Highlands rock types. These rocks range in age from the billion year old Pre-Cambrian to the glacial sediments of the last few thousand years.

Finally, Larry Müller provide some fascinating information on the famous "Cape May diamonds". These are not diamonds at all, but rather a semi precious gem of quartz, one of the most abundant minerals on earth. Nevertheless, some of the stones have been fashioned into a variety of popular rhinestone jewlery. It is thought that the quartz pebbles collected as "Cape May diamonds" were brought to the area with Pleistocene gravel at the end of the last ice age.

The Survey welcomes your feedback on the content or format of the newsletter (http://www.njgeology.org/comments.html). Other recent geologic activities and digital publications of the Survey are noted in the newsletter and elsewhere on the Survey's Web site. Printed maps and reports are available to the public through the DEP Maps and Publications Office (609) 777-1038, PO Box 438, Trenton, N.J. 08625-0438 and a publications price list is maintained on the Web. Unpublished information is provided at cost by writing the State Geologist's Office, N.J. Geological Survey, PO Box 427, Trenton, N.J. 08625-0427. Staff are available to answer your questions 8 a.m. - 5 p.m. Monday through Friday by calling (609) 292-1185.

Karl W. Muessig,
New Jersey State Geologist

Figure 1. A sentinel and a million-dollar view. Eastern State Line Monument overlooks the Hudson River and affords leaf-off views of New York from Yonkers to Manhattan. *Photos by Z. Allen-Lafayette*

SENTINELS AT THE NORTHERN BORDER

By Bill Graff

WATERY BOUNDARY

As a state with water on three sides, New Jersey's boundary is unique. It is 487 miles long and about ninety percent water. Hawaii is the only state whose borders are comprised of more water than New Jersey. Our water boundary is comprised of 137 miles of Atlantic Ocean, 164 miles of Delaware River shared with Pennsylvania, 76 miles of Delaware River and Bay that neighbor Delaware, and 60 miles of water along New York, including Hudson River, Upper New York Bay, Kill van Kull, Arthur Kill and Raritan Bay.

The remaining ten percent of the New Jersey state boundary, about 50 miles, is on land. About two miles of the land boundary were created in the early twentieth century when dredging spoils were placed in the Delaware River adjacent to our boundary with Delaware. Less than a mile of it was determined in 1998 when the U.S. Supreme Court ruled that Ellis Island in Upper New York Bay is part of both New Jersey and New York. The remaining 48 miles of our land boundary lie between the Hudson and Delaware Rivers and comprise our northern border with New York.

Figure 2. One sentinel, two rivers, three states. Western State Line Monument overlooks the confluence of the Delaware and Neversink Rivers and Tri-States Monument.

EARLY SURVEY

The New Jersey-New York land boundary featured prominently in the early work of the New Jersey Geological Survey. In 1872, New Jersey's first State Geologist, George H. Cook, was granted permission by the New Jersey Geological Survey Board of Managers to survey the northern border. Cook asked to undertake this work for several reasons. The western end of the boundary had not been precisely defined and many of the 48 small stone monuments installed in the first survey in 1774 were missing or may have been moved. Also, local surveys showed that the 1774 monuments were not in a straight line, which was in conflict with the wording of the 1664 grant conveying New Jersey from the Duke of York to Lord John Berkeley and Sir George Carteret.

Cook enlisted the assistance of Professor Benjamin Peirce, Superintendent of the U.S. Coast Survey, to determine the latitude and longitude of the western end of the New Jersey-New York land boundary. Peirce dispatched surveyors to the confluence of the Delaware and Neversink Rivers who located the western terminus for Cook. Cook also hired Edward A. Bowser, a Rutgers mathematics professor, to survey the boundary. Bowser found that about one third of the boundary monuments from 1774 were in fact missing.

He also found that the boundary was not one straight line, but a series of irregular segments that arced to the south of the intended line toward New Jersey. Bowser's calculation shows the greatest deviation along the boundary was twenty-six miles west of the Hudson River near Greenwood Lake, where it was 2415 feet south of the straight-line border. Much of the error was attributed to the use of a magnetic compass that was unknowingly effected by the New Jersey Highlands magnetic iron ore belt in the 1774 survey. As a result, about ten square miles of land originally intended for New Jersey was inadvertently placed in New York.

One month after Bowser's survey, New Jersey Geological Survey published a 48-page report titled "Report on a Survey of the Boundary Line between New Jersey and New York, made in July and August, 1874" for the Board of Managers and Governor Joel Parker. The report included a history of the boundary since its creation in 1664 and the results of Bowser's survey. In the conclusion, Cook wrote, "Some joint action should be had with the State of New York, by which the line could be straightened, and made to accord with its original definitions and descriptions."

Over the next several years, Cook worked to straighten the boundary line. He was named as a boundary commissioner in 1876 along with two prominent New Jerseyans, Abraham Browning, who coined "The Garden State" as our state

Figure 3. Three states at once. New Jersey, New York and Pennsylvania meet at Tri-States Monument.

nickname, and Thomas N. McCarter, founder of McCarter & English, today our largest law firm. They worked with three New York commissioners, Chauncey M. Depew, general counsel for the New York Central Railroad, Elias W. Leavenworth, a U.S. Congressman, and Henry R. Pierson, a former state Senator.

The New Jersey commissioners were to direct the relocation of the boundary and either have new boundary monuments erected or repair those installed in 1774. Not surprisingly, New Jersey proposed relocating the line, but New York did not agree. Eventually the two State legislatures decreed that the boundary according to the 1774 monuments, and its inherent southern arc, would be considered the true land boundary. In 1882, the commissioners had new monuments placed adjacent to the 1774 monuments at one-mile intervals west from the Hudson River. Boundary monuments were also placed at sixty-eight highway and

NJGS
1835

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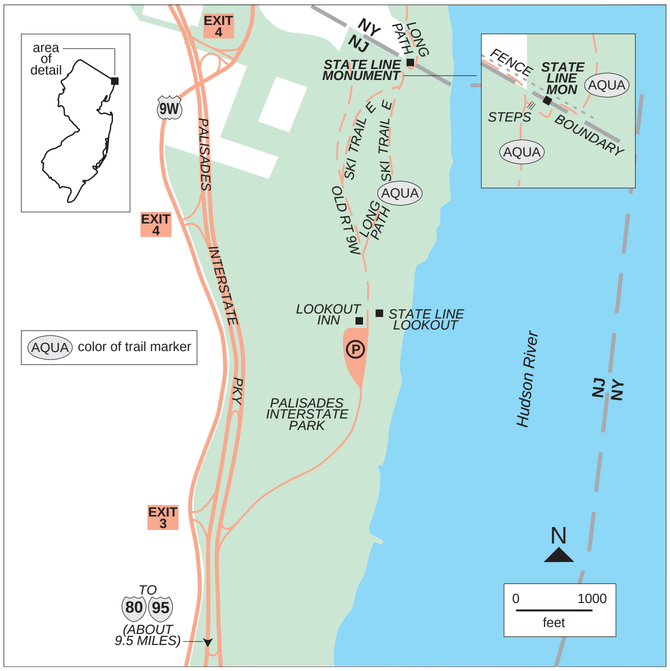


Figure 4. Eastern State Line Monument is in Palisades Interstate Park just north of State Line lookout.

railroad crossings between the Hudson and the Delaware Rivers. The 1774 boundary monuments were not repaired. Today about one-third of the boundary markers from both 1774 and 1882 are missing and presumed destroyed.

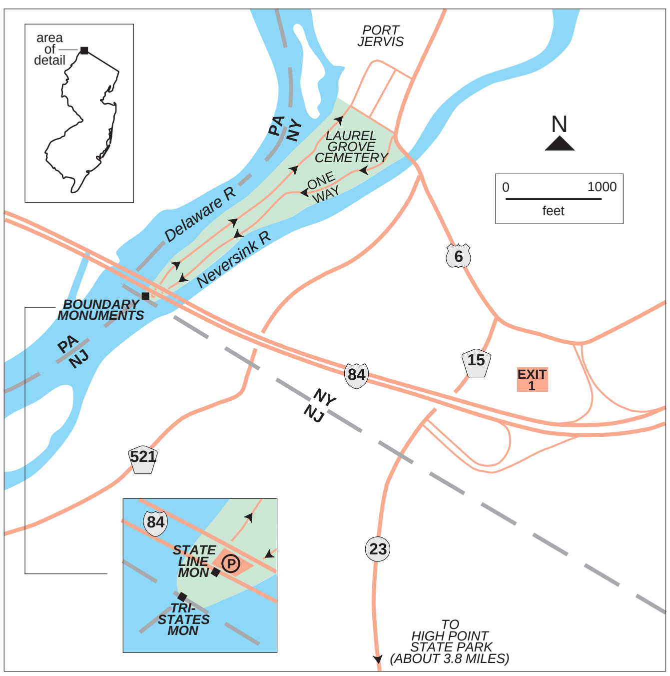


Figure 5. Western State Line Monument and Tri-States Monument are at the confluence of the Delaware and Neversink Rivers, about five miles north of High Point State Park.

SENTINELS

State Geologist Cook and his fellow commissioners insured their work on the New Jersey-New York land boundary would not be forgotten. While most of the 116 monuments installed by the boundary commission are quite modest, projecting either six inches or one foot above ground, the monuments at the eastern and western ends of the boundary are truly special. Overlooking the Hudson and the Delaware are two unique granite monuments that stand as sentinels at the border. They guard symbolically our only significant segment of land boundary and serve as proud representations of state sovereignty for both New Jersey and New York.

The eastern monument is referred to as State Line Monument (fig. 1). This 7.5-foot-tall granite shaft is located exactly on the northern boundary about 350 feet above the Hudson River at the edge of the Palisades. It is also 488 feet from the easternmost end of the New Jersey-New York land boundary, a spot called Station Rock, a large, inaccessible block of trap rock on the bank of the Hudson.

A similar State Line Monument (fig. 2) stands near the western end of the boundary overlooking the Delaware at its confluence with the Neversink River. This shaft, also of granite, is slightly shorter than its eastern counterpart and is not exactly on the boundary. Known as a witness monument because its distance to the boundary has been established, it is located in New York 72.25 feet north of the boundary.

Just down a short, sandy and rocky slope from State Line Monument at the western terminus of the boundary is Tri-States Monument (fig. 3). Located at a place called Carpenter's Point, this small granite slab serves as both the northern end of our boundary with Pennsylvania and the northwestern end with New York.

Both of the granite sentinels that overlook the Hudson and the Delaware are accessible to visitors. The eastern State Line Monument can be viewed as part of a hiking trip in Palisades Interstate Park (fig. 4). Western State Line Monument and Tri-States Monument are easily reached with a short drive north from High Point State Park (fig. 5). When visiting Tri-States, remember to stand in three states at once!

SUGGESTED WEB SITES:

High Point State Park - www.state.nj.us/dep/parksandforests/parks/highpoint.html

Palisades Interstate Park - www.njpalisades.org

FURTHER READING:

Cook, G.H., 1872, Annual report of the State Geologist for the year 1872: New Jersey Geological Survey, 44 p.

Cook, G.H., 1873, Annual report of the State Geologist for the year 1873: New Jersey Geological Survey, 128 p.

Cook, G.H., 1874, Annual report of the State Geologist for the year 1874: New Jersey Geological Survey, 115 p.

Cook, G.H., 1874, Report on a survey of the boundary line between New Jersey and New York made in July and August, 1874: New Jersey Geological Survey, 48 p.

Snyder, J.P., 1969, The story of New Jersey's civil boundaries, 1606 - 1968: New Jersey Bureau of Geology and Topography, Bulletin 67, 294 p.

van Zandt, F.K., 1976, Boundaries of the United States and the several states: U.S. Geological Survey Professional Paper 909, 191 p.

THE NEW JERSEY GEOLOGICAL SURVEY AND THE 2006 WATER SUPPLY PLAN

By Steven Domber

INTRODUCTION

A key component of the New Jersey Water Supply Management Act of 1981 is the requirement that the Department of Environmental Protection (DEP) periodically update the State Water Supply Plan (WSP). The WSP is meant to balance recreational, potable, ecological and economic water needs to ensure that adequate, reliable, and environmentally sustainable water supplies remain available into future, especially during drought. The New Jersey Geological Survey (NJGS) is taking a lead role in quantifying water use and water availability as part of the current revision of the WSP which was last revised in 1996.

WATER TRANSFER DATA MODEL

A first step in determining how much water is available for use in the future is to calculate how much is used today, where it is used, and for what purpose. To accomplish this, NJGS developed a computer program called the New Jersey Water-Transfer Data Model (NJWaTr). The model uses data from many water-related programs within the DEP and other state and federal agencies. It allows the analysis of water withdrawals, uses, transfers and discharges within any region of the state defined by the model user. Data can be summarized for easy comparison of withdrawals from different sources, water-use categories, trends within watersheds or a combination of other parameters. Data can also be analyzed for temporal or spatial trends by water source, use or discharge. Three examples are illustrated here. For each of New Jersey's five Water Regions, figure 1 shows the source: unconfined ground water, confined ground water or surface water. Figure 2 shows the use of the withdrawn water. Table 1 summarizes 1990 and 1999 statewide withdrawals for each of the seven water-use categories as a percentage of the total. It also shows the change in withdrawal for each category from 1990 to 1999, and the percentage change from 1990 to 1999 within each use category. In general, the data show that total state-wide withdrawals over the 1990's decreased slightly and that potable supply and power generation comprise about 80% of the state's total withdrawals. Additionally, the withdrawal type, source and trend can change from region to region within the state. For example, while total use has decreased in northeastern New Jersey, consumptive use is increasing. Consumptive use is the portion of total use that is lost to evapo-transpiration. This change is likely due to a shift from industrial and commercial uses (primarily non-consumptive)

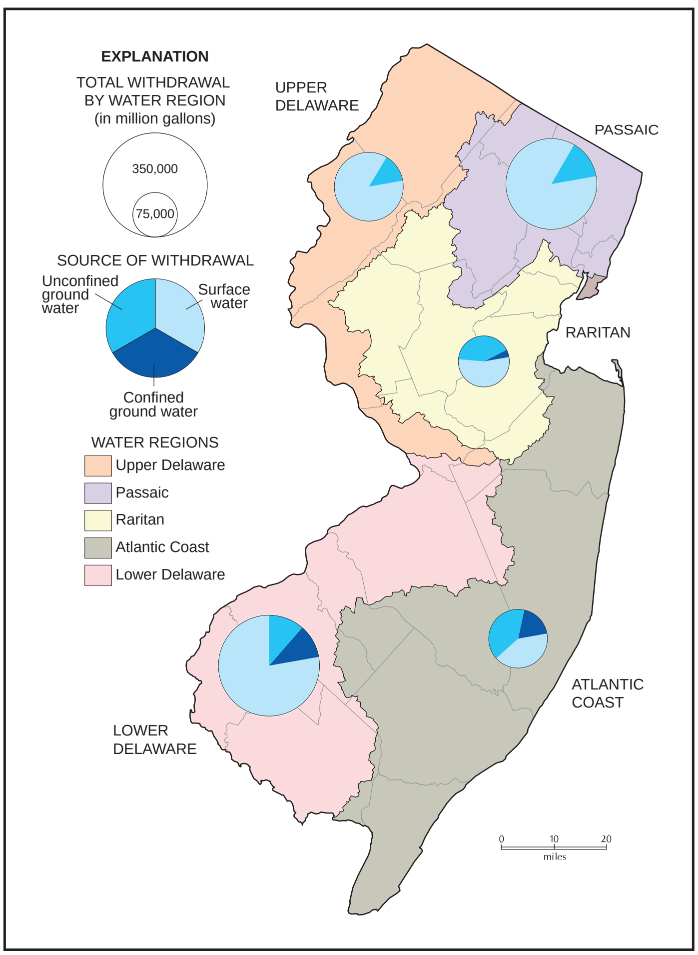


Figure 1a. Source of water: unconfined ground water, confined ground water or surface water.

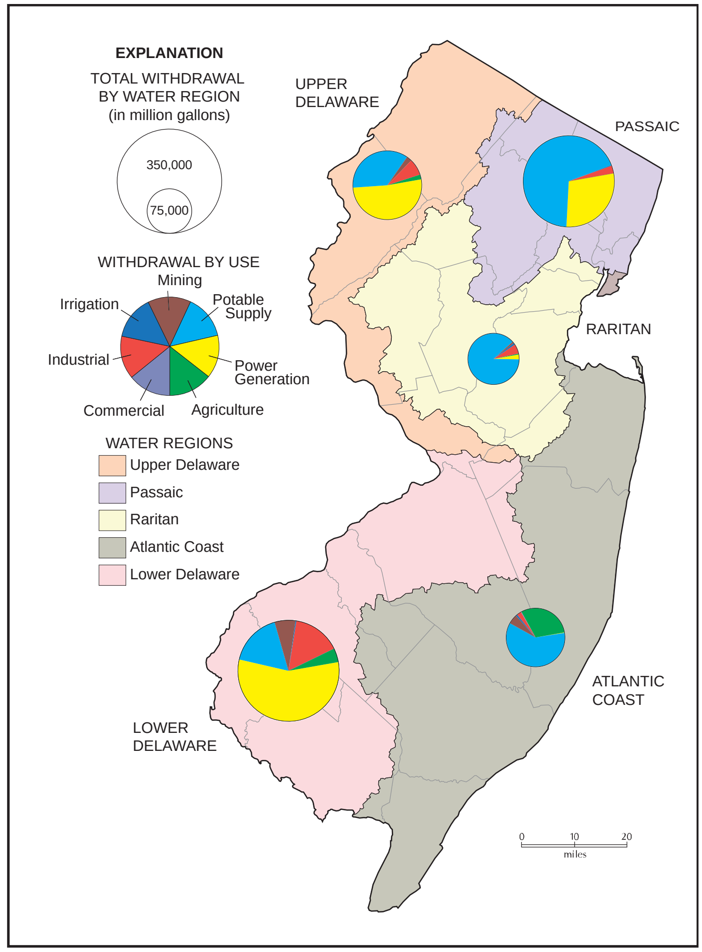


Figure 1b. Use of withdrawn water.

to potable use (which includes consumptive uses such as lawn watering). When consumptive uses are compared, agricultural and potable supply account for approximately 80% of the total volume (in contrast to potable supply and power generation previously cited under total withdrawals). Use and withdrawal trends vary and are determined by the scale of the analysis. In addition, the significance of the identified trends depends on the hydrologic setting and conditions in each region.

Once current patterns are understood, future use projections can be more accurately analyzed. As table 1 shows, potable supply accounts for almost 50% of total and consumptive use in New Jersey, illustrating the importance of accurate estimates of future potable water needs.

STATEWIDE WATER WITHDRAWALS

Use Group	Percent of 1990 total withdrawal	Percent of 1999 total withdrawal	Change, in million gallons, 1990-1999	Percent change within use group
Agricultural	5	7	16,000	35
Commercial	1	<1	-68	-15
Industrial	9	7	-23,000	-27
Irrigation	1	2	1,500	74
Mining	3	4	4,500	17
Potable supply	42	48	25,000	6
Power generation	39	31	-116,000	-25
Total	100	100	-92,000	-8

Table 1. Statewide water withdrawals.

FUTURE NEEDS

Because the majority of potable water is used residentially, population projections can be used to predict future needs. According to 2000 census, New Jersey's population was 8.4 million and according to NJWaTr data for 1999, the annual withdrawal for potable water was approximately 467 billion gallons. This equates to an average of 152 gallons of water per person per day. Projections suggest that the population of New Jersey will increase to 10.1 million people by 2030. Using these figures, an additional 94 billion gallons of potable water per year will be needed by then. Of course, where this water will be needed will depend on where the population growth occurs within the state.

Future need for agricultural water is more difficult to predict because it is dependant on precipitation patterns and crop types. There has been a recent increase in water-intensive agricultural products, such as lawn turf and vegetables, as well as an increase in landscape nursery and greenhouse operations. As a result, the total acreage farmed may decrease but water use may increase. Again, trends within sub-regions of New Jersey are likely to vary greatly depending on a large number of factors.

The use of water by commercial, industrial, irrigation, mining and power generation is expected to remain relatively constant. However, individually these diversions may have a significant hydrologic impact at the local level.

WATER BUDGET

Current and future withdrawals must be put in the context of the larger water budget. A water budget is a quantitative assessment of the various components of the hydrologic cycle which consists of rainfall, evapotranspiration, runoff, recharge, ground-water discharge and stream flow. A water budget can be relatively simple and quantify only a few hydrologic components. For example, precipitation equals total stream flow plus evapotranspiration averaged over several years. NJGS is currently researching a more complex water budget, attempting to quantify multiple components of the hydrologic cycle over short time periods (months and days). In particular, the NJGS is attempting to quantify components of the hydrologic cycle which contribute to stream flow. The goal is to devise tools that will assess impacts due to human modification of one or more component of the hydrologic cycle.

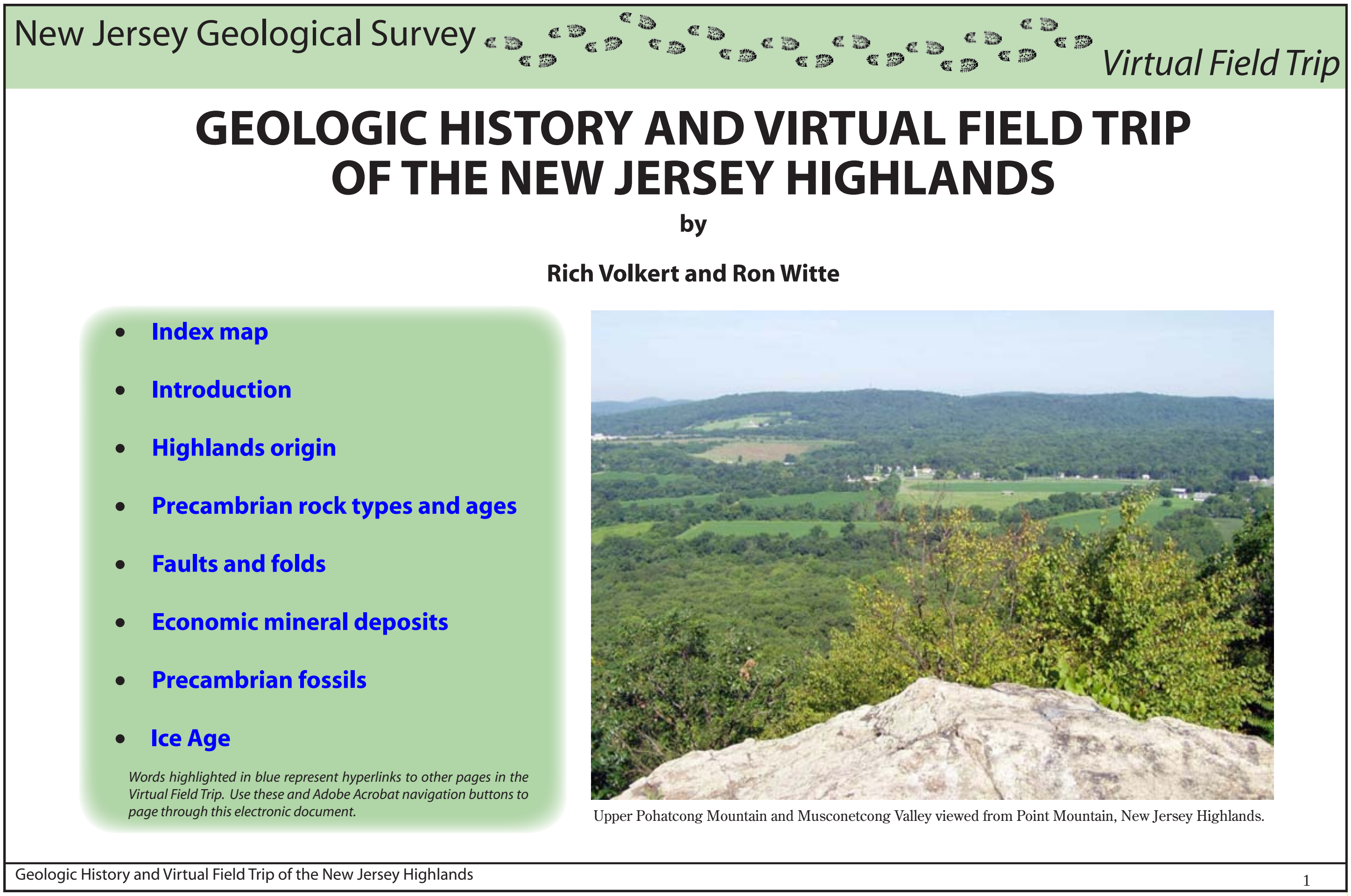
An understanding of the "natural" or unaltered water budget is needed before the effects of human modifications can be inferred. Model development and calibration is a difficult and data-intensive process that is further complicated by the fact that many New Jersey streams have already been altered by people. NJGS is developing a water budget method to test several "natural" watersheds and compare them to other available hydrologic indicators within the time frame of the 2006 Water Supply Plan.

One hydrologic indicator to be tested is the stream-base-flow-margin method. The method is defined as the difference between the annual 7-day minimum streamflow which can be expected to occur on average once in 10 years (known as the 7Q10), and the September median flow for a particular watershed. The 7Q10 can be thought of as an extreme low flow. On average, September is the month with the lowest stream flows and can be thought of as the normal low flow for an average year. Most of the flow during this time of year is from ground-water discharge rather than surface-water runoff. To prevent water withdrawals from turning a normal low flow into an extreme low flow, water loss from the watershed must not exceed this volume. As a safety factor, especially in areas of ecological significance, only a small fraction of the margin may be available for depletive (water exported outside the watershed) and consumptive uses.

Withdrawals that capture and store flood or high season flows will use a different calculation to estimate water availability. Additionally, water availability from New Jersey's confined coastal plain aquifers is estimated using existing groundwater models and other criteria.

NJGS is in the process of quantifying current and projected water withdrawals and availability for all of New Jersey's watersheds and confined aquifers. When this work is complete, NJGS will incorporate this work into the WSP. The current revision of the New Jersey Water Supply Plan is expected to be completed by December 2006.

SiO_2



New Jersey Geological Survey — Virtual Field Trip

GEOLOGIC HISTORY AND VIRTUAL FIELD TRIP OF THE NEW JERSEY HIGHLANDS

by

Rich Volkert and Ron Witte

- Index map
- Introduction
- Highlands origin
- Precambrian rock types and ages
- Faults and folds
- Economic mineral deposits
- Precambrian fossils
- Ice Age

Words highlighted in blue represent hyperlinks to other pages in the Virtual Field Trip. Use these and Adobe Acrobat navigation buttons to page through this electronic document.

Upper Pohatcong Mountain and Musconetcong Valley viewed from Point Mountain, New Jersey Highlands.

Geologic History and Virtual Field Trip of the New Jersey Highlands 1

Title page from Geologic History and Virtual Field Trip of the New Jersey Highlands. Click on title page to link to the virtual field trip.

VIRTUAL FIELD TRIP

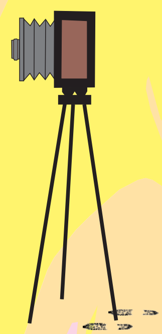
By Ron W. Witte

Now available as an on-line publication is a *Geologic History and Virtual Field Trip of the New Jersey Highlands.* This interesting educational resource is found at www.njgeology.org and can be downloaded as an Adobe acrobat document. The "field trip" consists of 100 pages of text, illustrations, and photographs that describe the origin of the Highlands, rock types and ages, faults and folds, economic mineral deposits, Pre-Cambrian fossils, ice age climate change and effects of multiple glaciations. More than 60 full-page photographs and a dozen illustrations that are linkable by key words and phrases take the reader on a virtual field trip through one of New Jersey's most scenic and historically rich regions.

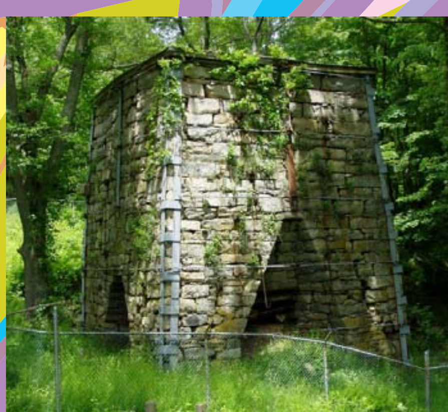
Tripod rock, Pyramid Mountain Natural Historical Area, Montville Township, Morris County

Pequest Valley at Great Meadows, Warren County.

Waterfall along the Wanaque River, Wanaque Wildlife Management Area, Passaic County.



Highlands Precambrian gneiss, Kinnelon, Morris County.



Furnace at Wawayanda State Park, Sussex County

Cape May diamonds. *Photo by J.H. Dooley*

CAPE MAY DIAMONDS

By F. L. Müller

The ocean's strandline has always fascinated beachcombers. The brilliant little stones they pick up regularly find their way into the pockets of young and old, and the shiny, water-clear ones have provoked dreams of diamonds. These fancies are likely responsible for the name "Cape May diamonds." However, like its cousins the "Lake George diamonds," "Herkimer diamonds," "Alaska diamonds," and "Cornish diamonds," they are not diamonds at all. Diamonds are precious gemstones of the element carbon. They are the hardest gemstones on Earth, 10 on the Mohs scale of hardness. Cape May diamonds are quartz, a semi precious gem of silica dioxide and considerably softer, a 7 on the Mohs scale. Diamonds are relatively scarce while quartz is one of the most abundant minerals of the continents.

Cape May diamonds have been fashioned into beautiful tie tacs, pendants, stick pins and broaches. Some rhinestones are actually faceted quartz. The "diamonds" have also been mounted in a variety of metals, and customers may find some of these in the gift shops of Cape May.

For over a hundred years Cape May diamonds have delighted visitors to this county. They are found all over, from the Atlantic beaches and Delaware Bay to local sandpits. Higbee Beach was a favorite collecting site but there is no actual place where the "diamonds" are concentrated. It is thought that the quartz pebbles were brought to this area with Pleistocene gravels at the end of the last ice age, and that the typical iron-yellow stain found on quartz pebbles was removed by the action of the tides and the breaking waves. In 1942, a 14-ounce Cape May diamond--over 2000 carats--was found. So look down, look for the sparkle; maybe you will find a larger one. But remember although a rose by any other name will smell as sweet, a diamond by any other name is probably not one.

REFERENCE

Wilkerson, A.S., 1959, Cape May diamonds: Minerals of New Jersey: The Geological Society of New Jersey, Report No. 1, Trenton, MacCrellish and Quigley Co., 30-31 p.

NEW PUBLICATIONS

GEOLOGIC MAP SERIES (GMS)

NEW MAP. Bedrock Geology of the Bridgeport and Marcus Hook Quadrangles, Gloucester and Salem Counties, New Jersey, Stanford, Scott D. and Sugarman, Peter J., 2006, scale 1 to 24,000, size 36x38, 3 cross-sections. GMS 06-1. $10.00

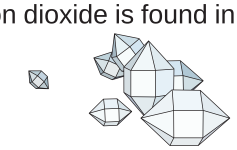
NEW MAP. Surficial Geology of the Bridgeport and Marcus Hook Quadrangles, Gloucester and Salem Counties, New Jersey, Stanford, Scott D., 2006, scale 1 to 24,000, size 36x38, 1 cross-section. GMS 06-2. $10.00

OPEN-FILE MAP SERIES (OFM)

NEW MAP. Quaternary Geology and Geologic Material Resources of Newton East Quadrangle, Sussex County, New Jersey, Witte, Ron W. and Monteverde, Don H., 2006, scale 1 to 24,000, 3 plates, sizes 22x37; 30x32; 32x34, 8 cross-sections, 1 figure, 2 tables, 14-page pamphlet. OFM 56. $30.00

NEW MAP. Surficial Geology of the Morristown Quadrangle, Essex and Morris Counties, New Jersey, Stanford, Scott D., scale: 1 to 24,000, size 36x53, 5 cross-sections, 1 figure, 36-page pamphlet. OFM 67. $10.00

Title banner: Cape May diamonds are quartz crystals (SiO_2), one of the most common minerals on earth. Quartz is a significant component of many igneous, metamorphic and sedimentary rocks. It occurs in hexagonal crystals or cryptocrystalline masses. Silicon dioxide is found in a wide range of colors and varieties.

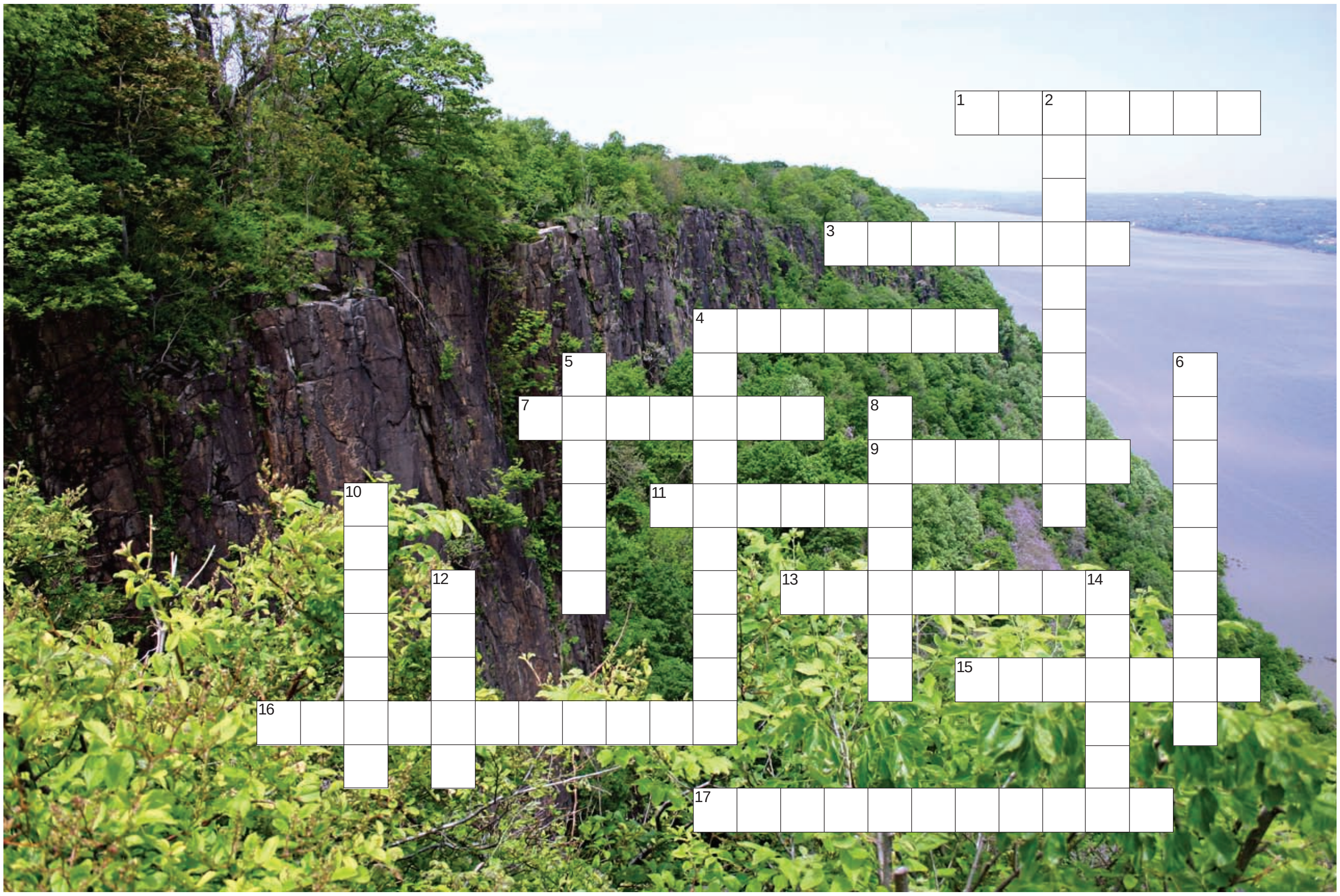


Title banner photos by J.H. Dooley

DELAWARE RIVER FLOODS

For the third time in as many years, the Delaware River flooded upstream from Trenton (shown here) in June, 2006. Visit www.nj.gov/dep/njflood/ for information about the New Jersey Flood Mitigation Task Force. *Photo by Z. Allen-Lafayette*

CROSSWORD CLIFFS



The New Jersey Palisades. *Photo by Z. Allen-Lafayette*

ACROSS

1. Artificial environment provided by a computer
3. Building block of molecules
4. Holocrystalline, quartz-bearing plutonic rock
7. Device that created an arc in New Jersey's northern border
9. Ellis
11. $Si0_2$
13. Having practical or industrial significance or uses; affecting material resources
15. Brilliancy; refraction of light
16. Earliest era of geological history
17. Epoch of the Quaternary period

DOWN

2. High luster imitation of a diamond
4. To cover with a glacier
5. A remnant, impression, or trace of an organism of past geologic ages preserved in rock
6. Standard by which the hardness of a mineral may be rated
8. Hard brilliant mineral that consists of crystalline carbon
10. Water-bearing stratum of permeable rock, sand, or gravel
12. Unit of weight for diamonds, pearls, and other gems
14. Diamond

SiO_2

"Geologic seeing is poetic vision constrained by the sobriety of science."
--Robert Frodeman--
2003

CROSSWORD PUZZLE ANSWERS. ACROSS: (1) Virtual, (3) Element, (4) Granite, (7) Compass, (9) Island, (11) Silica, (13) Economic, (15) Sparkle, (16) Precambrian, (17) Pleistocene. **DOWN:** (2) Rhinestone, (4) Glaciation, (5) Fossil, (6) Mohs scale, (8) Diamond, (10) Aquifer, (12) Carat, (14) Carbon.